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May 12, 1959

Encl. #1 to
GUS-0260
COPY 1 OF 2

PROGRESS REPORT NO. 3

and

4 1/2-MONTH SUMMARY REPORT

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by

AIRFRAME MANUFACTURER COORDINATION

The sixth coordination meeting was held on April 9, 1959, and in addition, several telephone conferences have occurred - during which areas of mutual interest have been better resolved, as follows:

1. Subsonic Duct

Delivery requirements for full scale subsonic inlet ducts to be used in engine ground tests have been modified. Delivery date for the first duct has been moved back to the last week in August and the second has been changed to October. This has provided relief in two areas. The lines of the duct are to be changed and the later delivery dates will allow the changes to be incorporated. Also, restricted funding would have prevented us from using a duct as early as 1 July as originally planned. Simple conical ducts will be used during early engine tests formerly planned with the more complex airplane subsonic duct.

2. Supersonic Inlet

Some changes in the inlet development program, affecting us, have been made. However, we have been able to adjust our program to accommodate these. The airframe contractor is now scheduling a 1/7 scale inlet model program at Langley in July - which we are counting on to yield required ramp position and shock position control information, as well as engine inlet air flow profiles.

Initial parameter information is to be available the first of August, with final information resulting from more complete analysis of the data being available on the 1st of September. Accordingly, we will eliminate an AEDC test which we had planned to be conducted jointly in August. An aerodynamic symposium was held at the airframe contractor's plant on 15 April, to make all available Marquardt experience accessible for consideration relative to the supersonic inlet development program.

3. Fuel System and Controls

A revised engine controls mode, as originally discussed in March and subsequently analyzed in detail by us, was agreed upon as a basis for final system design. The change was from pilot lever control of variable exit position to pilot lever control of exhaust

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total temperature. This provides some simplifications to the system and offers more assurance against over-temperaturing of the engine. It was also agreed that the maximum fuel temperature requirement would be reduced from 500°F to 450°F - which reduces the control development problem somewhat and ground tests facility requirement considerably.

An engine installation drawing incorporating the cut-off plug nozzle was sent the airframe manufacturer on 1 May. Length is reduced from 91.23" to 77.68" and engine weight is reduced from 920 lbs to 880 lbs.

5. Inlet Controls

Requirements for arrangement of the inlet controls has been established as follows:

The ramp system will involve two independent controllers and two independent actuators. One of the controllers will be on standby, while the two actuators will be synchronized in the airplane to operate together except in case of hydraulic failure - in which case one actuator alone will handle normal operating requirements at high altitudes. The bypass system will include an independent controller and actuator for each duct.

Most pilot functions relative to engine control have been established. We are now working with tentatively agreed upon lever positions and are initiating discussion of required engine data readouts for the instrument panel.

6. Engine Deliveries

Initial requirements for engine deliveries have been established by the airframe contractor and will provide a basis for discussion during the 7th coordination meeting now scheduled for the 13th and 14th of May.

CUSTOMER COORDINATION

Budget problems discussed in the Second Progress Report have been largely resolved. Estimates of advance material order requirements to provide against a steel strike and advanced orders for special test equipment have been revised downward by $120,000. Also, cancellation of one subsonic duct has allowed recovery of about $74,000 for the program. In addition, $160,000 extra funding was received to account for the change in the contracting period from 4 to 4 1/2 months. Some other small savings, due to experience of lower average pay rate than originally projected, etc., have also resulted since the March 24th review of program costs. Review of the schedule position of the items of work indicates that as of the 12th of May, the overall 25-month schedule could still be held.

Late in March, a list of 61 stock listed machine tools was submitted as a requirement for the 25-month development program. Also included were 21 non-stock listed items such as work benches, etc. Since then, we have screened tool lists at Warner Robbins and Production Equipment Redistribution Group and have found 26 of the stock listed items. Holds have been requested on all of these and inspection of them has been started. Two of the tools are required immediately and separate correspondence has been furnished on these (Reference (A)). The remaining tools are required on very tight schedule as summarized in Reference (B). We are preparing a list of special test equipment items which could be used on this job and we will require permission for hold and inspection on them. This list should be mailed prior to May 16.

We are now planning on an expenditure total of $2,150,000 to be reached on approximately July 1. The six additional weeks of low input rate, between May 15 and July 1, will result in a one month extension to the program. Flight Readiness Test engines then would be available in 20 months and Operational Suitability Test engines in 26 months.

ADMINISTRATIVE

The proposal for the 25-month development program has been completed and was mailed on March 26. The proposal for manufacture of the initial blocks of engines was not mailed on the 15th of April as planned, but is being withheld pending establishment of the required engine delivery schedule.

There are now about 219 employees working on this job, with 187 of this number located in two closed areas (shop and school building). A total of 324 personnel security checks have been requested (of this number 28 have been requested to be deleted due to transfer, etc.). A total of 68 clearances have been received to date.

Liaison Conducted From March 31 to May 12, 1959

Date	Place	Representation Additional to Engine Manufacturer	Purpose
3-31-59	AEDC (Tenn.)		Expedite nozzle tests
4-9-59	Fort Worth	Others	6th coordination meeting

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Table Continued - Liaison Conducted From March 31 to May 12, 1959:

Date	Place	Representation Additional to Engine Manufacturer	Purpose
4-15-59	Fort Worth	[redacted]	Inlet symposium
4-17-59	Van Nuys		Technical review
4-24-59	Van Nuys	E. Kiefer J. Parangosky	Schedules and spending rates - reviewed
5-1-59	Van Nuys	E. Kiefer J. Parangosky	Review program controls and proposal
5-7-59	Fort Worth	[redacted]	Pre-contractual meeting on the bleed air turbine
5-13-59	Fort Worth		7th coordination meeting

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COMPONENT TESTS

The Fluidyne Engineering Corporation exit nozzle model test program has been completed. All models have been run and, following final calibrations scheduled for the week of May 11th, data will be forwarded to us.

Setup of the exit model balance system at AEDC has been completed and tests there are scheduled to begin the week of May 11th. It is planned that modifications of the basic shapes evaluated at Fluidyne will be tested to develop the shape yielding optimum performance.

Combustion development has been concentrated on improving efficiencies with the current burner design at the trajectory condition of ramjet takeover (M = 2, 36,000 feet). Duct segment tests have shown low efficiencies at this condition, using RJ-1, with specification efficiency being obtained at Mach numbers of 2.4 and higher. Systematic tests with various fuel blends indicate that specification performance at this condition can be achieved with the following fuels: 80 octane gasoline, JP-4, blend containing 18% gasoline and 82% RJ-1, blend containing 10% gasoline and 90% RJ-1.

The airframe manufacturer may be able to tolerate the small amount of blended fuel that would be required for acceleration up to M = 2.4. If not, injection modifications providing preheating of the fuel are indicated.

Approximately six weeks of segmental duct testing have been accomplished during the program.

Further tests are being conducted with the 30-inch engine. Small changes indicated by segmental duct testing have been incorporated and the affects of blends, including more volatile fuels, are being checked. Initial flight simulation ignition tests show the engine will light three times out of three with three spark plugs and three times out of six with one spark plug.

MOCK-UP

Drawing release for the mock-up is 100% complete and it is estimated that 55% of its manufacture has been completed. It is basically an external lines mock-up made from aluminum and metal and its main purpose is to provide the airframe manufacturer a basis for visualizing any installation problems. The exit nozzle is a fixed plug simulating the cruise position. Fuel, air, electrical, and control rod connections will incorporate actual hardware where its final design is now known. Internal engine details will not be incorporated in the mock-up at this time. Delivery date to the airframe contractor is June 15.

FIRST ENGINE STRUCTURE

Design of the first engine is approximately 90% complete. A planned drawing release schedule as compared with the actual is shown in Figure 1.

The large departure in the actual curve during April is due to a complete change in the exit nozzle configuration from the convergent-divergent plug to the cut-off plug design.

Approximately 20% of the manufacturing of the first engine has been completed. Rene' 41 and all other sheet metal required has been received and fabrication of parts has been initiated. The following parts are in noticeable stages of completion:

- Nose cone
- Diffuser skins
- Longeron frames
- Structural ring - forward innerbody
- Innerbody sheet metal rings
- Clips, brackets, angles (approx. 20 items)
- Longeron attach angles
- Longeron skins

We encountered problems in attempting to heat treat our first 40-inch dia. Rene' 41 test ring. It was made by rolling up a bar and flash welding it to form a ring. Machining to proper section was accomplished as anticipated. However, the ring warped during the heat treating process. We are now investigating the cause of warpage. The material vendor has indicated that the bar stock may not have been supplied per specification, which would have affected its heat treatability. Also, the hold-down fixture we designed might have been at fault. We are currently conducting liaison with Ryan Aeronautical Company relative to their recent experience in manufacture of Rene' 41 afterburner parts.

FUEL SYSTEMS AND CONTROLS

Design of the fuel and control system is approximately 51% complete. A plot of planned accomplishment vs actual is shown in Figure 2. Drawing status of the engine contained equipment is shown in Figure 3, which is a reduction of the assembly drawing in its current status of completion.

Expedited casting procurement will require elimination of the competitive bid system normally used. Accordingly, we have considered the three casting vendors who have been used in the Bomarc engine program and have selected Hills-McCanna of Chicago, Illinois, as the one most suitable for our job. We plan to have a Hills-McCanna representative start working with us on the designs, beginning May 18, in order to incorporate detailed foundry "know how" in the initial layouts. It is hoped that this procedure will eliminate casting design modification that has resulted in some delay in other programs.

The first breadboard package, consisting of a modified Bomarc control unit together with a simulated engine centerbody and duct, have been completely designed and are now under construction. Fabrication will be approximately 35% complete on May 15, with tests scheduled to begin on May 25. These tests will furnish heat transfer information required for some of the design considerations of the final package system.

Block diagrams for the engine control, ramp control, and bypass control systems, are shown in Figures 4, 5, and 6.

The following initial analyses of the fuel and control system have been completed:

1. Sensitivity of all controllable engine parameters (and induction system characteristics) was determined to verify the choice of controlled variables.

2. Fuel control system tolerances have been estimated for the most important operating conditions. In terms of fuel-air ratio, they are as follows:

   At ramjet takeover F/A tolerance is ±5%

   At the end of the acceleration period F/A tolerance is ±6%

Pilot lever adjustment can reduce these errors to values approaching zero, depending on accuracy of read-out instrumentation. During cruise, the control scheme selected results in pilot lever control of fuel-air ratio as required to maintain the proper flight path.

3. Analysis has been completed for matching fuel pressure requirements for all elements of the system, beginning with the fuel injectors - working upstream through the flow regulating elements, fuel pump, and back to supply pressure. Careful consideration in this matching has resulted in an inherently extremely reliable fuel injector system without requirement for unduly high pump output pressure.

Aerodynamic data on supersonic inlets for integral engine installations, as obtained by NASA and others, has been investigated and correlated to determine existance of suitable parameters which should be available in the specific inlet being designed by the airframe manufacturer. It has been determined that a fairly simple signal - such as the ratio of diffuser outlet pressure over diffuser inlet pressure - may serve as a shock position parameter.

SUMMARY OF WORK ACCOMPLISHED RELATIVE TO THE CONTRACT WORK STATEMENT

A summary of work completed in accordance with Paragraph A of Exhibit A, as ammended per Ammendment #1, dtd February 24, 1959, is shown in the following table:

Contract Work Statement	Work Accomplished
a. Perform initial performance analysis.	a. Initial performance analysis has been accomplished which has resulted in a tentative engine and control system specification.
b. Prepare a tentative engine and control system specification.	b. A preliminary engine and control system specification was furnished the airframe contractor on Feb. 11, 1959 - per Reference (c). This specification has been modified and improved to include all subsequent agreements and was reissued on May 12, 1959.
c. Upon availability of the high pressure station of the gas dynamics facilities, AEDC, perform continuous model scale aerodynamics testing of the variable exit nozzle.	c. AEDC nozzle test facility became available to us for model installation on April 20. Installation proceeded, with testing scheduled to start on May 15. Completion of this initial series of tests is now

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Contract Work Statement	Work Accomplished
c. - continued	predicted for approximately June 12, 1959. Due to late availability of AEDC, nozzle tests were also run at Fluidyne.
d. Perform approximately three standard weeks of large scale component combustion testing in Cell #3 of the Air Force Marquardt Jet Laboratory.	d. Approximately 3.8 standard weeks of large scale combustion testing, using the 30-inch dia. test engine, will have been completed in Cell #3 of the Air Force Marquardt Jet Laboratory as of May 14, 1959.
e. Initiate flight type engine design and construction. It is anticipated that approximately 80% of the design of the first flight type engine will be completed.	e. 90% of the design of the first flight engine has been completed and approximately 20% of the fabrication has also been accomplished.
f. Initiate design and construction of the fuel and control system. It is contemplated that approximately 30% of the design and construction of the first breadboard fuel and control system will be completed during the period.	f. Design of the flight type fuel and control system has been initiated and has reached the 51% completion point. In addition, 100% of the design of the first breadboard system has been completed and approximately 35% of the construction has also been accomplished.
g. Initiate construction of the engine mock-up. It is contemplated that approximately 50% of the mock-up will be completed during the period.	g. 100% of the design of the mock-up has been accomplished, along with approximately 55% of the construction.
h. Place on order long lead time equipment and material items and take such other actions as may be necessary to support the anticipated continuation of the program beyond the initial 4 1/2-month period.	h. Long lead time equipment such as machine tools, basic test facilities, and specialized testing equipment has been requested. In addition, material and tooling for the second and third engines has been placed on order along with certain long lead time special test equipment items.

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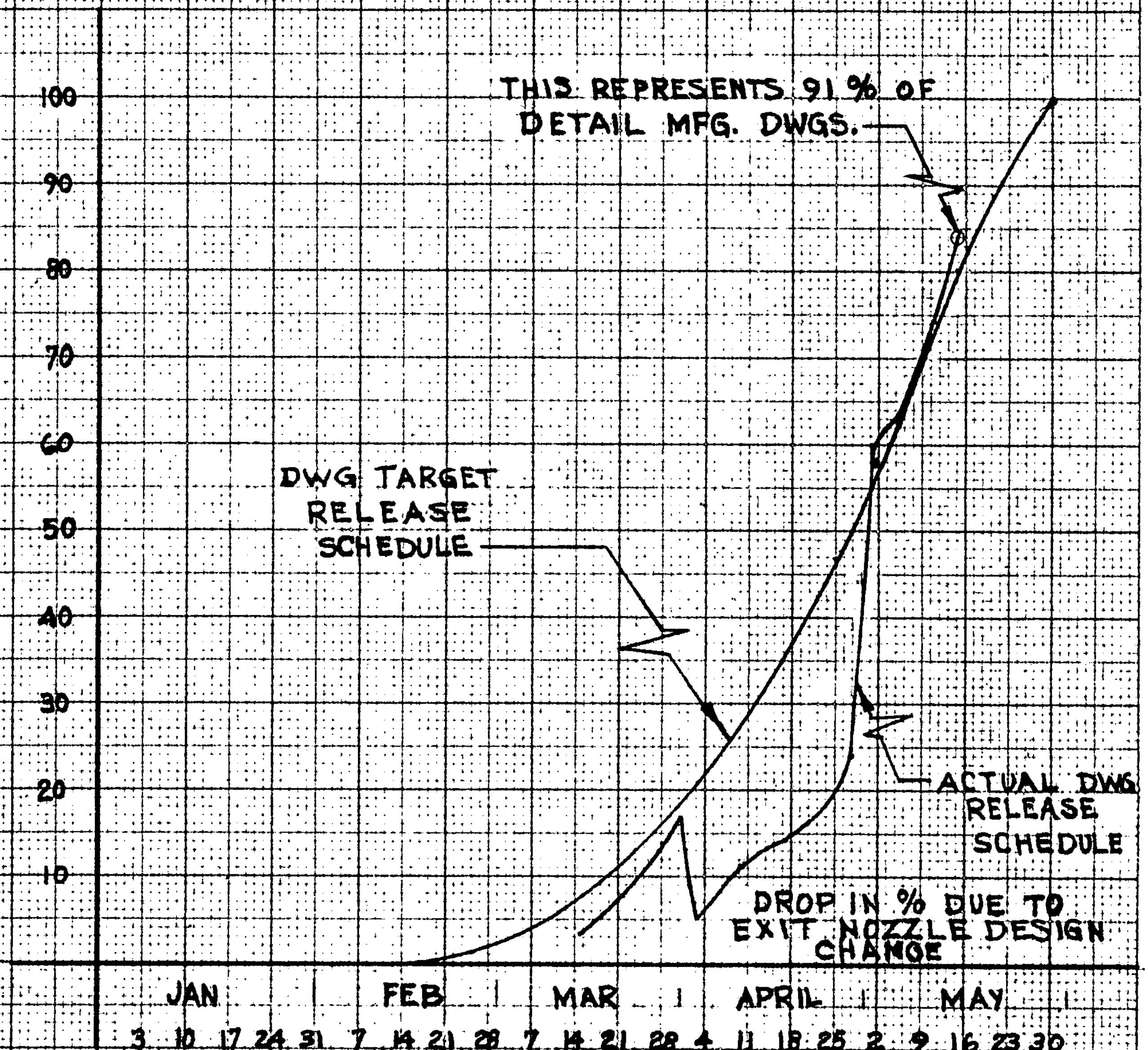

FIRST ENGINE DESIGN RELEASE SCHEDULE

Planned and Projected Actual

as of 15 May 1959

FIG. 1

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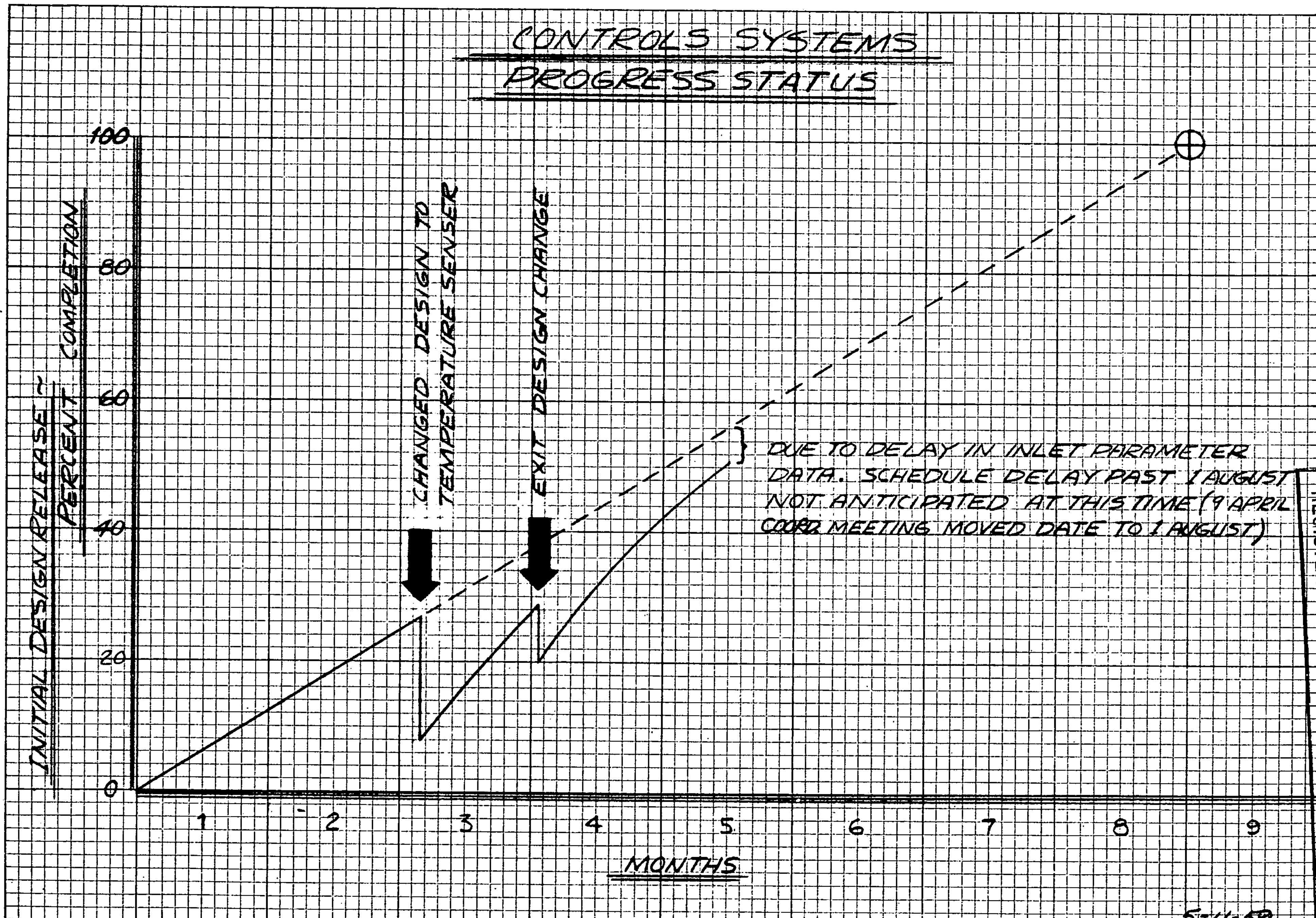

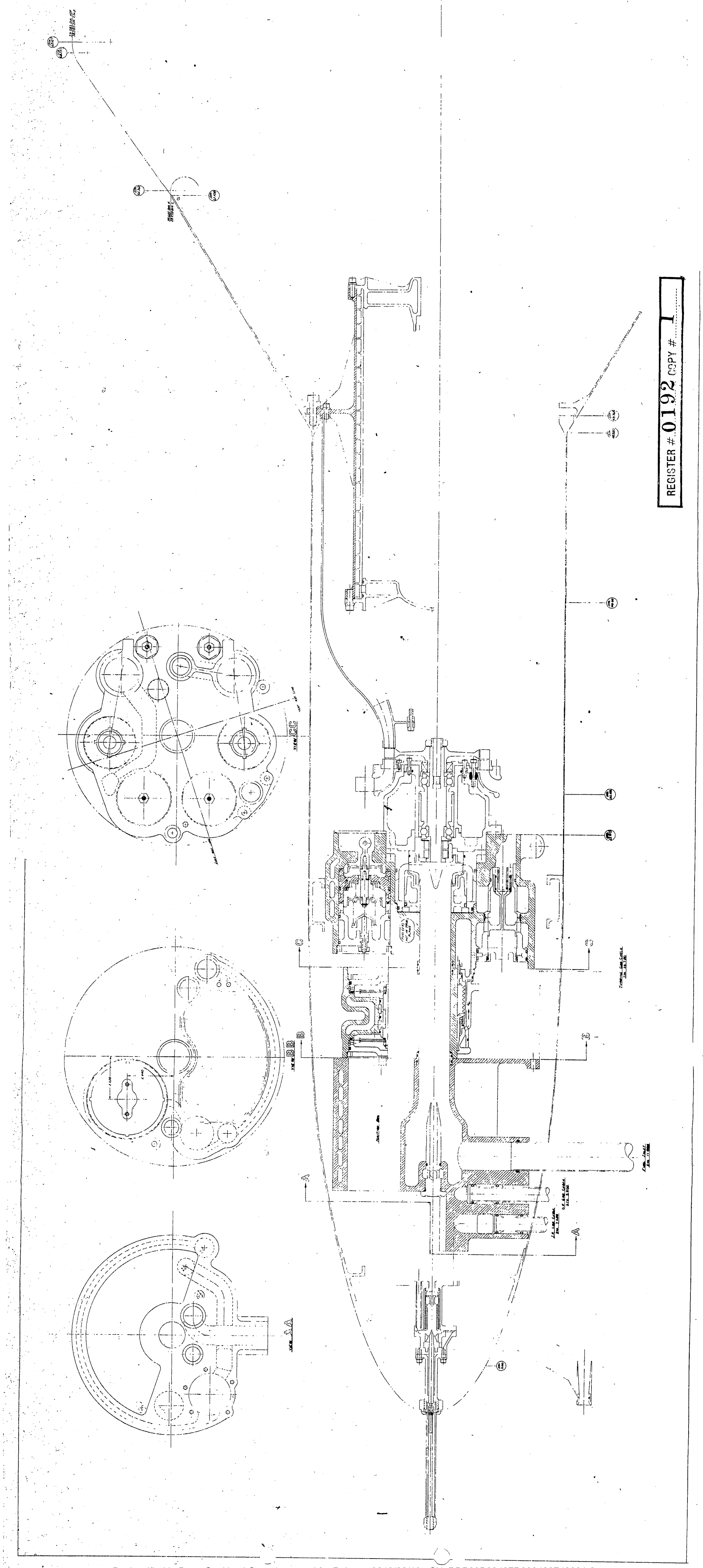

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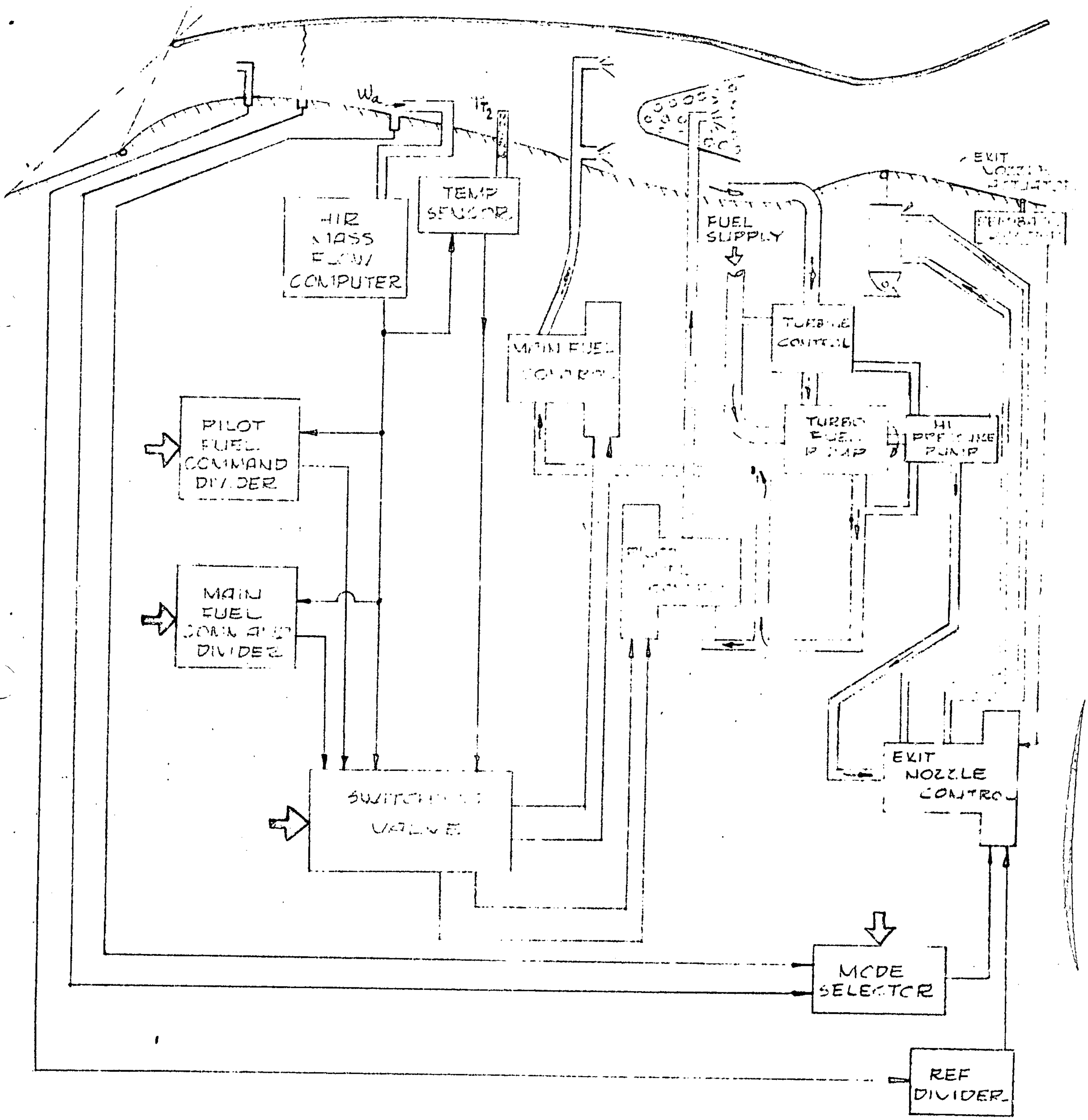
SIMPLIFIED ENGINE FUEL CONTROL SYSTEM SCHEMATIC



= PILOT INPUT

BLOCK DIAGRAM-RAMP CONTROL SYSTEM

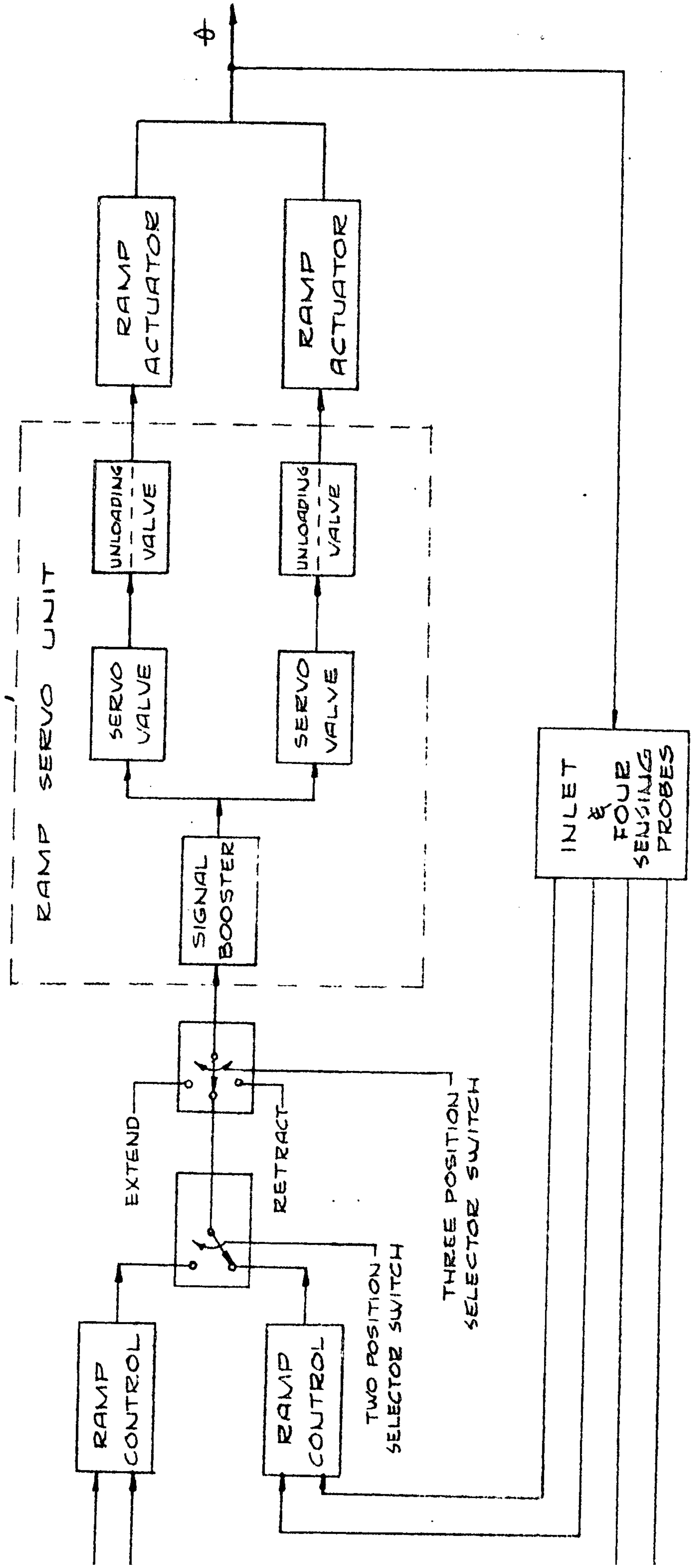


FIG. 5

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BLOCK DIAGRAM ~ BY-PASS CONTROL SYSTEM

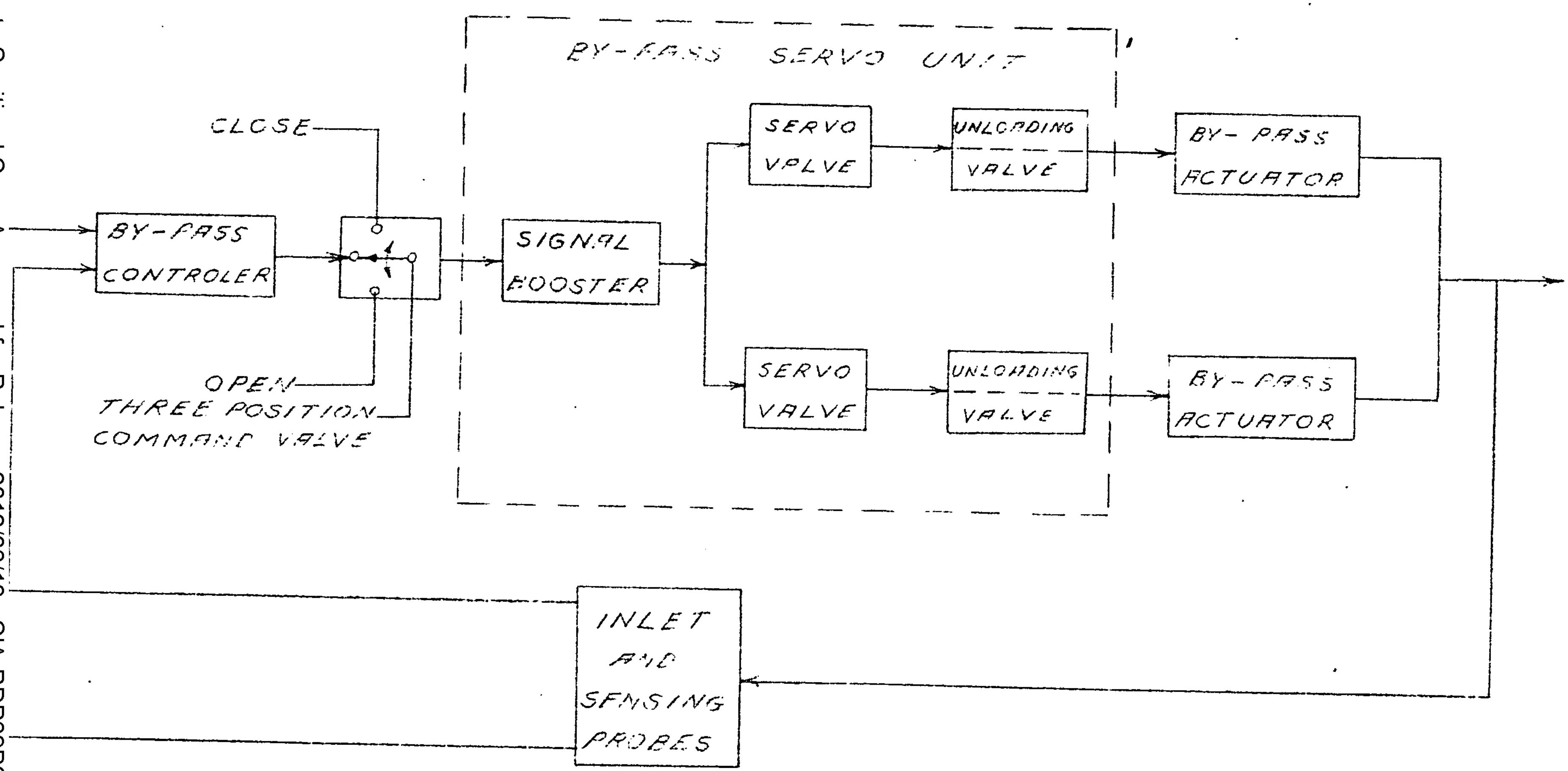

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FIG. 6

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